# PHYSICAL SCIENCES INFORMATICS (PSI)

The Physical Sciences Informatics (PSI) is an online database of completed physical science reduced-gravity flight experiments conducted on the International Space Station (ISS), Space Shuttle, Free Flyers, or commercial cargo flights, and of related ground-based studies. It includes experimental data from the following six research areas: 1) Biophysics, 2) Combustion Science, 3) Complex Fluids/Soft Matter, 4) Fluid Physics, 5) Fundamental Physics, and 6) Materials Science. Each research area is represented through a variety of data types, including raw and analyzed data, imagery, science requirements, experiment design and engineering data, analytical and numerical models, publications, reports, patents, and commercial products developed from the research.

The goals of PSI are to a) promote investigations making use of currently available experimental data resulting in more scientists participating in reduced-gravity research; b) allow new areas of research and discovery to occur more quickly through open access; and c) accelerate the "research to product or publication" timeline through the rapid sharing of data. The PSI system allows researchers access to the detailed experimental data obtained from flight research conducted as part of NASA's Physical Sciences Research Program. In line with NASA's commitment to fostering an inclusive open science community, PSI serves as an Open Science Data Repository (OSDR). NASA's Biological and Physical Science (BPS) division releases an annual call for proposals soliciting ground-based research proposals to utilize the experimental data in the PSI system.

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Find more information on these investigations and others at psi.nasa.gov

*The **Advanced Colloids Experiment-Temperature Control (ACE-T) series** of microgravity investigations looks at the 3D behavior of many classes of micron-sized particles. The ACE-T1 experiment uses Janus particles to control how fast particles rotate which effects how fast they translate or stay in a location, important for timed and targeted delivery of cosmetics or pharmaceuticals. The ACE-T6 experiment aims to better understand how to design and build commercial products and studies depletion attraction in the presence of Soret diffusion to better understand stabilizers that extend a product's shelf-life. This is a multi-billion-dollar concern for P&G. ACE-T11 allowed scientists to create large 3D defect-free FCC crystals from hard spheres that will be important for confirming fundamental models and for controlling infrared light.*

## ACE-T1

Advanced Colloids Experiment-Temperature Control-1 (ACE-T1) studies Janus particles with one half of their surface composed of hydrophilic groups and the other half of hydrophobic groups. Materials having complex structures and unique properties potentially can be made with more knowledge of how these particles are joined together and conditions controlling their behaviors. ACE-T1 addresses these fundamental questions about behaviors of colloids to better understand the fundamental physics of micro-particle self-assembly and the kinds of colloidal structures that are possible to fabricate.

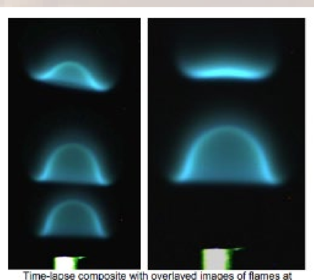
## ACE-T6

Advanced Colloids Experiment-Temperature-6 (ACE-T6) studies the microscopic behavior of colloids in gels and creams, providing new insight into fundamental interactions that can improve product shelf life. Colloids are suspensions of microscopic particles in a liquid, and they are found in products ranging from milk to fabric softener. Consumer products often use colloidal gels to distribute specialized ingredients, for instance droplets that soften fabrics, but the gels must serve two opposite purposes: they have to disperse the active ingredient so it can work yet maintain an even distribution, so the product does not spoil. This research was a collaborative effort between P&G, CASIS and NASA.

## ACE-T11

Advanced Colloids Experiment-Temperature Control and Gradient Sample-11 (ACE-T11) involves the design and assembly of complex three-dimensional (3D) structures from colloids, or small particles suspended within a fluid medium, and control of particle density and phase behavior. Such structures are vital to the design of advanced optical materials and important for 3D printing and additive manufacturing. Assembling structures in microgravity provides insight into the relation between particle shape, crystal symmetry, density, and other fundamental factors.

## ACME CLD Flame


Time-lapse composite with overlayed images of flames at varying flow conditions (above the coflow burner's inner tube) from two tests shown at different scales.

The Coflow Laminar Diffusion Flame (CLD Flame) experiment has yielded high-fidelity quantitative measurements of axisymmetric flames of gaseous fuel that can provide a rigorous testbed for verifying computational models. The investigation, one of six in the Advanced Combustion via Microgravity Experiments (ACME) project, focused on two extremes: highly dilute flames close to extinction and highly sooty flames. Fuel and air velocities, typically matched in testing, were varied allowing study of extinction and stability limits, including flame detachment from the burner.

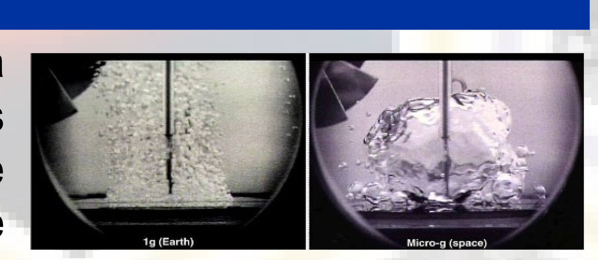
## SUBSA CETSOL

Predicting the metal casting process is an ongoing challenge due to gravitational effects on the solidification process. Buoyancy-driven melt convection can create local differences in fluid density, affecting the microstructure of cast parts. These microstructural changes – for instance, the macrosegregation of unattached solids, such as equiaxed grains – can affect the properties and quality of cast parts. The Columnar-to-Equiaxed Transition in Alloy Solidification (SUBSA-CETSOL) studies the effects of convection on dendrite fragmentation and subsequent nucleation by comparing samples with varying solute buoyancies solidified in the microgravity environment and on Earth. Specifically, it investigates whether pre-frontal nucleation of equiaxed grains is needed for a columnar-or-equiaxed transition or whether fragmented dendrites can cause this transition. Better understanding of how buoyancy affects solidification can benefit industrial production of cast metals.

## SUBSA BRAINS

BRAzing of Aluminum Alloys IN Space (SUBSA BRAINS) investigates capillary flow phenomena relevant to techniques of brazing in microgravity for space construction and repair. A series of microgravity and terrestrial experiments integrate with modeling and numerical simulations. The applied aspects include direct verification if brazing of Al alloys is transferable to orbit for rapid repair of the pressure wall or construction. For the first time, brazing in space has been processed using the patented flux-less Trillium technology.

## PBE

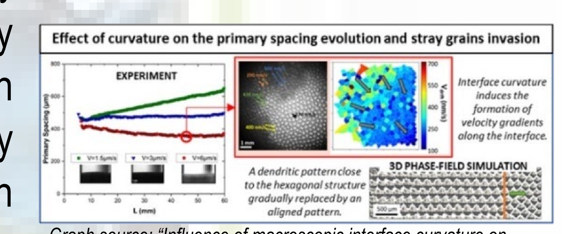


Liquid heated to boiling point in 1-g, generating vapor bubbles that rise.

The Pool Boiling Experiment (PBE) was a series of five Space Shuttle experiments that advanced the understanding of the fundamental mechanisms that constitute nucleate pool boiling. PBE investigated the heat transfer and vapor bubble dynamics associated with nucleation, bubble growth or collapse, and subsequent motion in a microgravity environment. The results from this and related research may lead to the development of more efficient electronic cooling of computer and instrumentation systems on spacecraft. This research was a precursor for more advanced microgravity pool boiling studies and flow boiling research applicable to spacecraft two-phase thermal control and power-cycle systems.

## DECLIC DSI-R

The main goal of the Directional Solidification Insert Reflight (DECLIC DSI-R) investigation is to quantitatively establish the fundamental physics controlling the spatiotemporal organization of the secondary side-branch structure and its interaction with the array structure of primary branches under directional solidification conditions. This investigation will directly address outstanding issues that remain open in the understanding of complex dendritic microstructures.



*Graph source: "Influence of macroscopic interface curvature on dendritic patterns during directional solidification of bulk samples: Experimental and phase-field studies," 2023 Acta Materialia*

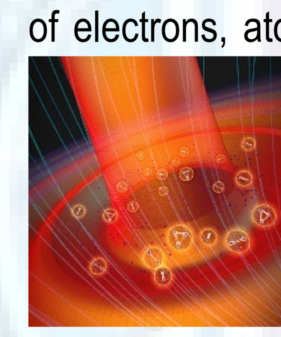
## PBRE-WR

Packed Bed Reactor Experiment- Water Recovery (PBRE-WR) investigates the role and effects of micro gravity on hydrodynamics of gas-liquid flow and delta pressure drops across various packed beds and flow restrictors: brine filter, urine filter, purge filter, check valve, various orifice sizes. PBRE-WR aims to develop and validate scaling laws and design tools for future packed bed reactors and flow restricting hardware in 0-g and partial-g environments, including start-up and transient operations, as well as identify strategies to recover single phase beds from undesired trapped gas bubbles.


Urine Transfer Filter from Packed Bed Reactor Experiment-Water Recovery

## CAL Few & Many Body Physics

Future advances in both technology and fundamental science will hinge on a better understanding of the weird effects of quantum mechanics on collections of electrons, atoms, molecules, and so on. Zero-G Studies of Few-Body and Many-Body Physics (CAL Few and Many Body Physics) probes the complex behaviors, dynamics, and molecule formation for quantum matter with widely varying (attractive and repulsive) interactions in the weightless environment found in an orbiting laboratory.



## RSD-AFF

Amyloid Fibril Formation in Microgravity via Ring-Sheared Drop (RSD-AFF) examines the formation and growth of amyloids and fibrils without the complications associated with the solid walls of a container, because in microgravity, surface tension provides containment of the liquid. Fibrous, extracellular protein deposits found in organs and tissues; amyloids are associated with neurodegenerative diseases such as Alzheimer's. Results could contribute to better understanding of these diseases as well as to development of advanced materials.

## STDCE-2

Surface-Tension-Driven Convection Experiment 2 (STDCE-2) is a continuation of the original investigation, STDCE-1 and aims to further the understanding of the physical mechanisms associated with oscillatory thermocapillary flow by (a) developing an accurate description of the physical mechanisms, (b) developing an accurate numerical model, and (c) obtaining ground-based and flight experimental data to verify the physical mechanisms and the numerical model.